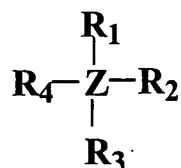


What is claimed is:

1. A capillary column comprising:
a tube structure including an inner surface; and
a sol-gel substrate bonded to a dendrimer substrate to form a sol-gel dendrimer matrix, wherein said sol-gel dendrimer matrix bonds to a portion of said inner surface of said tube structure to form a surface-bonded stationary phase coating thereon.
2. The capillary column according to claim 1, wherein said sol-gel substrate is made from sol-gel precursors having the general structure:



wherein,

Z = a precursor-forming element selected from the group consisting of silicon, aluminum, titanium, zirconium, vanadium, and germanium; and

R₁, R₂, R₃, and R₄ = R-groups are moieties selected from the group consisting of sol-gel-active moieties, alkoxy moieties, hydroxy moieties, non-sol-gel-active methyl, octadecyl, and phenyl.

3. The capillary column according to claim 2, wherein said alkoxy groups are selected from the group consisting of a methoxy group, ethoxy group, *n*-Propoxy group, *iso*-Propoxy group, *n*-butoxy group, *iso*-butoxy group, and *tert*-butoxy group.
4. The capillary column according to claim 2, wherein one to two said R-groups are moieties selected from the group consisting of alkyl moieties and their derivatives, alkenyl moieties and their derivative, aryl moieties and their derivatives, arylene moieties and their derivatives, cyanoalkyl moieties and their derivatives, fluoroalkyl moieties and their derivatives, phenyl moieties and their derivatives, cyanophenyl moieties and their derivatives, biphenyl moiety and its derivatives, cyanobiphenyl moieties and their derivatives, dicyanobiphenyl moieties and their derivatives, cyclodextrin moieties and their derivatives, crown ether moieties and their derivatives, cryptand moieties and their derivatives, calixarene moieties and their derivatives, liquid crystal moieties and their derivatives, dendrimer moieties and their derivatives, cyclophane moieties and their derivatives, chiral moieties, and polymeric moieties.
5. The capillary column according to claim 4, wherein two to three said R-groups

are moieties selected from the group consisting of methyl, octadecyl, phenyl, and hydrogen.

6. The capillary column according to claim 1, wherein said dendrimer substrate is made from monomers selected from the group consisting of isocyanates, isocyanates with benzyl ether terminal groups, t-butyl isocyanate monomers, and bis-homotris compounds, 4-amino-4-[1-(3-hydroxypropyl)]-1,7-heptanediol, 4-[1-(3-aminopropyl)]-4-[1-(3-hydroxypropyl)]-1,7-heptanediol, aminotriols, quaternary nitroalkanes, and other cascade monomers.

7. The capillary column according to claim 6, wherein said isocyanates are of the formula of $O=C=N-C(CH_2-R)_3$,

wherein R is selected from the group consisting of:

- a) $-CH_2-tbu$;
- b) $-(CH_2)_n-CH_2-COOR'$;
- c) $-O-(CH_2)_n-CH_2COOR'$;
- d) $-O-(CH_2)_n-CH_2-CN$; and
- e) $-(CH_2)_n-CH_2-O-R''$.

R' being selected from the group consisting of alkyl (C-1 to C-20), cycloalkyl (C-3 to C-10), aryl, heteroaryl, polycycloalkyl, and adamantyl; and

R'' being selected from the group consisting of alkyl, cycloalkyl, aryl, $-CO-R'''$, $-CS-R'''$, $-SO_2-R'''$, $-SiR'''_3$, $-(CH_2)_n-CH_2-CN$, and $-(CH_2)_n-CH_2-COOR'''$;

wherein R''' is alkyl (C-1 to C-20), cycloalkyl (C-3 to C-10), aryl, heteroaryl, polycycloalkyl, adamantyl, $n=0-10$ in all formulas.

8. The capillary column according to claim 1, wherein said sol-gel substrate further includes a residual of a deactivation reagent selected from the group consisting of polymethylhydrosiloxane, hexamethyldisilazane, 1,1,1,3,3,3-hexamethyldisilazane, hydrosiloxane, and hydrosilane.

9. The capillary column according to claim 1, wherein said sol-gel substrate further includes at least one baseline stabilizing reagent residual selected from the group consisting of residuals from bis(trimethoxysilylethyl)-benzene, sol-gel active reagents with phenyl-containing groups, and cyclohexane-containing groups.

10. The capillary column according to claim 1, wherein said tube structure is made of materials selected from the group consisting of glass, fused silica, alumina, titania, and zirconia.

11. A method of making a sol-gel and dendrimer solution for placement into a capillary column having inner walls by:

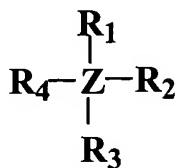
- mixing suitable sol-gel precursor(s) and sol-gel active dendritic moieties to form a sol-gel solution;
- hydrolyzing the sol-gel-active precursor(s) and dendritic moieties to form hydrolyzed products;

polycondensating the hydrolyzed products into a sol-gel dendrimer network; and

surface bonding the sol-gel dendrimer network on a portion of the capillary inner walls to form a surface bonded sol-gel dendrimer stationary phase coating thereon.

12. The method according to claim 11, wherein said mixing step further includes adding trifluoroacetic acid as the catalyst.
13. The method according to claim 12, wherein said mixing step further includes adding an additional catalyst selected from the group consisting of acids, bases or fluorides.
14. The method according to claim 11, wherein said hydrolyzing and polycondensating steps occur within the sol-gel solution placed inside the capillary column.
15. The method according to claim 11, wherein said deactivating step occurs at elevated temperatures during column conditioning.
16. The method according to claim 11, including the step of deactivating the sol-gel dendrimer stationary phase.
17. The method according to claim 11, including the step of hydrothermally pre-treating the capillary column.
18. A gas chromatography column comprising:
 - a capillary column including a tube structure having an inner surface; and
 - a sol-gel substrate bonded to a dendrimer moiety to form a sol-gel dendrimer matrix, wherein said sol-gel dendrimer matrix bonds to a portion of said inner surface of said tube structure to form a surface-bonded stationary phase coating thereon.
19. A capillary column comprising:
 - a tube structure including an inner surface;
 - a stationary phase coating attached to at least a portion of said inner surface; and
 - dendrimer moiety chemically bonded to said stationary phase coating for selectively interacting with various analytes.

20. The capillary column according to claim 19, wherein said stationary phase coating includes a sol-gel substrate made from sol-gel precursors having the general structure:



wherein,

Z = a precursor-forming element selected from the group consisting of silicon, aluminum, titanium, zirconium, vanadium, and germanium; and

R₁, R₂, R₃, and R₄ = R-groups are moieties selected from the group consisting of sol-gel-active moieties, alkoxy moieties, hydroxy moieties, non-sol-gel-active methyl, octadecyl, and phenyl.

21. The capillary column according to claim 20, wherein said alkoxy groups are selected from the group consisting of a methoxy group, ethoxy group, *n*-Propoxy group, *iso*-Propoxy group, *n*-butoxy group, *iso*-butoxy group, and *tert*-butoxy group.

22. The capillary column according to claim 20, wherein said R-groups are at least two moieties selected from the group consisting of alkyl moieties and their derivatives, alkenyl moieties and their derivatives, aryl moieties and their derivatives, arylene moieties and their derivatives, cyanoalkyl moieties and their derivatives, fluoroalkyl moieties and their derivatives, phenyl moieties and their derivatives, cyanophenyl moieties and their derivatives, biphenyl moiety and its derivatives, cyanobiphenyl moieties and their derivatives, dicyanobiphenyl moieties and their derivatives, cyclodextrin moieties and their derivatives, crown ether moieties and their derivatives, cryptand moieties and their derivatives, calixarene moieties and their derivatives, liquid crystal moieties and their derivatives, dendrimer moieties and their derivatives, cyclophane moieties and their derivatives, chiral moieties, and polymeric moieties.

23. The capillary column according to claim 22, wherein remaining said R-groups are moieties selected from the group consisting of methyl, octadecyl, phenyl, and hydrogen.

24. The capillary column according to claim 19, wherein said dendrimer means is a substrate made from monomers selected from the group consisting of isocyanates, isocyanates with benzyl ether terminal groups, *t*-butyl isocyanate monomers, and bis-homotrimer compounds, 4-amino-4-[1-(3-hydroxypropyl)]-1,7-heptanediol, 4-[1-(3-aminopropyl)]-4-[1-(3-hydroxypropyl)]-1, 7-heptanediol, aminotriols, quaternary nitroalkanes, and other cascade monomers.

25. The capillary column according to claim 24, wherein said isocyanates are of the formula of O=C=N-C(CH₂-R)₃,

wherein R is selected from the group consisting of:

- a) $-\text{CH}_2\text{-tbu}$;
- b) $-(\text{CH}_2)_n\text{-CH}_2\text{-COOR}'$;
- c) $-\text{O}-(\text{CH}_2)_n\text{-CH}_2\text{COOR}'$;
- d) $-\text{O}-(\text{CH}_2)_n\text{-CH}_2\text{-CN}$; and
- e) $-(\text{CH}_2)_n\text{-CH}_2\text{-O-R}''$.

R' being selected from the group consisting of alkyl (C-1 to C-20), cycloalkyl (C-3 to C-10), aryl, heteroaryl, polycycloalkyl, and adamantyl; and

R'' being selected from the group consisting of alkyl, cycloalkyl, aryl, $-\text{CO-R}'''$, $-\text{CS-R}'''$, $-\text{SO}_2\text{-R}'''$, $-\text{SiR}'''_3$, $-(\text{CH}_2)_n\text{-CH}_2\text{-CN}$, and $-(\text{CH}_2)_n\text{-CH}_2\text{-COOR}'''$;

wherein R''' is alkyl (C-1 to C-20), cycloalkyl (C-3 to C-10), aryl, heteroaryl, polycycloalkyl, adamantyl, $n = 0-10$ in all formulas.

26. A method of preparing a capillary column by simultaneously deactivating, coating, and immobilizing a sol-gel dendrimer stationary phase on a tube structure.

27. The method according to claim 26 further defined as chemically bonding the sol-gel dendrimer stationary phase to an interfacial organic-inorganic polymer layer, the polymer layer evolving over a surface of the tube structure.

28. A separation and extraction apparatus comprising a stationary phase of a sol-gel bonded to a dendrimer moiety, said stationary phase bonded to a surface.

29. A separation and extraction phase comprising a sol-gel bounded to a dendrimer moiety.